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Informational Asymmetries in the Food Industry

A unified perspective

Master's Thesis
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Master's Economics
Spring 2018

Abstract

The food industry is rife with opportunity to cheat on quality. This is because producers cannot easily provide or prove claims of their quality. We see evidence of this in the news, government studies and in supermarkets with products vying for shoppers' patronage. Furthermore this problem has sparked a literature filled with policy prescriptions ranging from better labeling to increasing auditing firms liability. This thesis will go over the literature and models and seek to ask how a coordinated set of policies could do even better.

1. Research Questions and motivation

The market for foodstuffs has changed considerably in the past century and continues to evolve rapidly – I'm sure drones will soon be delivering our dinners. But there is one problem, that in my humble opinion, has not gotten much better from the days of Upton Sinclair's *The Jungle* and that is the glaring lack of transparency in the consumptive process. To quote David MacLennan the CEO of Cargill, a large American Agribusiness, "In the absence of information, people will make up their own story." It is precisely this informational asymmetry that forces consumers to take a leap of faith when making a purchase. This leap of faith is more or less scary depending on where we live – but nevertheless I will investigate in my thesis this ever-present aspect of the market that plagues us all, or at least marginally reduces our welfare.

The focus of this thesis will be the theoretical source of informational asymmetries in the food industry, its perniciousness, historical evolution and consequences, primarily in the provisioning of quality. The natural questions are where do these problems come from and what can we do about them? One way to think about it is the following: When we go to a store, do the choices we make and those of producers represent the social optimal?

Another related question is the following: the claim has been made that if a market for something does not exist, it is because people have such preferences and do not value the good in said market. Does this claim apply to the food industry? Is the market for organic goods and premium brands small because people don't value such goods, or has the market broken down in some way. Answering this question is of practical interest to us all, as well as policy makers. But I would also like to explore another question as I proceed – how are existing policies working? This questions stems from the observation that in my research, the policy suggestions are often quite simple. But are they working? What evidence is there of successes and failure of policy?

The motivation for this thesis is primarily to investigate a problem that affects us all on a daily basis and provide a *complete* set up policy recommendations. That is,

solving the problem requires and end-to-end solution stemming from a theoretical understanding of each potential problem area in the market. Answering the question necessitates that we take a broad view and dive deeper to unwrap and understand a phenomena. This thesis will not refute any of the suggestions from the literature, but will however point out their impotence. Progress is not to suggest another, albeit effective, regulation but will give us the pieces needed to effectively consider an over-arching institutional change. As Acemoglu and Robinson point out in *Why Nations Fail*, "Institutions, intuitions, institutions". I hope that the ideas presented will be broadly applicable; I do not aim to discover the only policies necessary to rectify moral hazard any particular sub-market within the food industry, but aim to analyze the features present in all corners that create the problem. The is not due to hubristic ambition but rather a belief that a common problem exists and hence shares a common set of policy prescriptions.

How to do this? I will start out with some evidence. Then, I will summarize the literature before moving deeper into selected models. Also I will be very clear about what I am investigating – what asymmetries am I taking about. For example are producers cheating after contracting, i.e. are there moral hazard problems. Or are they taking steps to conceal information from the outset. I will model the market in a way that highlights why this market is particularly vulnerable to such exploits.

2. Preliminaries

1.1. Evidence

It will be useful to take a look at some examples of these asymmetries being taken advantage of, as well as some consequences. Our media is rife with examples and unfounded claims – likely due to the fact that as Johnson (2014)[1] in a Congressional Research Service Report succinctly states,

[1] His report provides a comprehensive overview of recent legislation and procedures aimed at mitigating the problem in the U.S.

> "those who commit fraud do not intend to cause physical harm and want to avoid detection. Most incidents go undetected since they usually do not result in a food safety risk and consumers often do not notice a quality problem. Moreover, as the motivation to commit fraud is illicit monetary gain, the type of food that might be or become adulterated is a secondary consideration (i.e., it could be any type of food or food ingredient); rather, it is the opportunity or feasibility of committing fraud that generally triggers the fraud."

A few concrete and well-researched examples follow:

Moore (2013) points out that the practice of adding melamine as way to boost apparent protein content has been going on for over 35 years and has been sickened thousands of Chinese infants and been directly contributed to several deaths as well as the death of thousands of household pets fed such enhanced food. Adding the chemical is allows watered-down food to test as having a higher protein content. It is also worth noting that his practice continues all over the world.

Another memorable case is when some European beef was in fact horse meat and mislabeled. In a report from the European commission in 2013, it became clear that the producers knowing mislabeled the meat. The incident led to a significant fall in public trust as well as to an investigation on a large scale because of fears of consequences from Phenylbutazone, a anti-inflammatory used on horses and is not approved for human consumption.

Another eye-opening example comes from the seafood industry. While buying a fillet of fish, or fish steak at a restaurant one can never be sure of many of its qualities. It must not make one sick of course, but the type of fish, and where it came from are just two attributes of interest that are nearly impossible to verify. A study for Oceanea (Warner et al. 2012) collected samples of fish from grocery outlets and sushi bars from all over the US and conducted DNA analysis to determine the truthfulness of the labels and found very high levels of mislabeling. They found that 58 percent of retail outlets mislabeled fish, for example passing off cheaper fillets of tilapia, or perch as the more

sought-after red snapper or halibut. *All* of the sushi bars sampled mislabeled some fish. Very often the substituted fish carry toxic levels of heavy metals or even have purgative effects hence explaining many people's aversion to 'bad sushi'. The example is instructive not just as fish can be easy to swap out, but because of the globalized nature of the fish market. The cheaper substituted fish often comes from markets that do not regulate the use of antibiotic for example or fish to depletion. The report is shocking in itself, but I would also like to highlight that it's conclusion that, "Without more transparency in the seafood supply chains and better labeling requirements for all seafood sold at retail outlets, fraud remains an open issue." This suggestion will become familiar from most of the literature.

I will mention below a few other everyday goods from Johnson's (2014) report that summarizes as well as underlines the fact of how vulnerable most everyday products indeed are. It also proves that as a society, we have a institutionalized problem. Transshipment is a problem with many goods, i.e. the practice of shipping a good through another country to hide its origin. This happens commonly with honey from China that is adulterated with, at best sugar, and at worst heavy metals and antibiotics banned in the US or EU. Olive oil is also commonly stamped with the 'Italian' label but really only bottled in Italy. In fact, olive oil in the US has been found to often contain no olive oil at all. Tea, coffee and spices are another easy target for adulteration with roasted twigs, saw dust, and carcinogenic dyes, to name a few. The list is expansive, but the point has been made – the problem is serious and wide-spread.

1.2.Literature review

As an obligatory starting point I want to discuss a model in Information Economics – The Market for Lemons, made famous by George Akerlof (1970). In his model, there are two types of cars, those of high quality and those of low quality, but consumers cannot tell the difference when they are shopping (of course the seller knows, but cannot credibly convince the buyers). Some arbitrary time after they buy, it becomes clear whether or not they bought a lemon. So, that's the game, while considering a particular car, what price should one offer (Akerlof doesn't represent the

game exactly like this, but the conclusion is the same)? The price for a high quality car would be too high because there is some chance that the car isn't of high quality. Anything price between high and low is also too high, because if the seller would accept we know that the car is a lemon, hence, the low price is the only rational price to offer. In the end, all the sellers of high quality goods have left the market. It is also worth pointing out that Akerlof provides another example with continuous types and the market breaks down entirely, i.e. no trade occurs even though agents are left wanting to trade and goods that they value exist.

This simple portrayal is powerful; there are conditions which imply a market with hungry buyers and sellers degenerates. I don't think that it is a stretch to claim that such informational asymmetries are indeed influencing the market. The only question is how much does current policies allow them to. Nearly every single paper mentioned in this thesis cites Akerlof. This is substantial evidence that theorists worry about a problem that cannot be easily solved, particularly in the food market.

Before moving further, we must take a look at some vocabulary popularized by Nelson (1970). Products have three types of attributes. Search attributes are those that can be determined at point of purchase by inspection. Experience attributes come after the product has been used/consumed. And credence attributes will not be learned by the consumer even after consumption. These distinctions will be useful when thinking about how consumers assess quality. It is also clear that information asymmetries arise most often when considering credence attributes, hence those good will be the focus of this thesis. Except in the case of food safety, these are often considered as experience goods for modeling simplicity. As always the definition is blurry and that's part of the problem.

The literature on informational problems in the food industry is broadly split into two categories, food-safety issues, and the rest, most of which focus on the organic market. Many of those then focus on one market feature leading to information asymmetry and suggest a remedy. For example, a oft-cited paper by Antle (2001) focuses on the informational problems along the supply chain and how those increase asymmetries at every step. Similarly, Starbird et al. (2008) point out that the inability to

trace food does nothing to incentivize producers to produce safe food. We will return to their model as it captures the phenomena in a tractable way and easily carries over to the organic market although the authors focus on safety issues. Using game theory as a way to model the problem is also very common. McCluskey (2000) shows that the market for credence goods simply cannot exist without monitoring. He goes even further and suggests under which conditions monitoring is likely to be effective.

Elbasha and Riggs (2003) take a different approach and show that double moral hazard causes the food industry to provide sub-optimal levels of safety. This is due to the fact that consumers cannot ensure that producers produce completely safe food, and the flip-side, producers cannot ensure that consumer properly handle the food. They suggest labeling as solution.

Unsurprisingly, there is also a large literature on contracting as most of the solutions involve some kind of contract. Hennesy (1996) suggests that vertical integration provides a way for more effective control of the supply chain.

Closely related to the contracting literature is a discussion on branding, which is a common suggestion to fight the problem. One illuminating example can be found after the collapse of the Soviet Union in the Moldovan milk market (Gorton et al. 2006). The authors investigate the market as a whole, and then proceed to analyze the features of one particular company, Molmilk, that managed to overcome the market's disfunctionalities.

Before the collapse, the central planners organized and controlled all the milk production in Moldova – the market was dominated by large organizations. After the collapse, like many markets in eastern Europe, the market was privatized with initially disastrous results – output fell from 1.5 million tons in 1991 to 600,000 tons in 2003 with small households accounts for 94% of milk production in 2003. As the authors point out, this can be attributed to factors other than the informational problems. But sorting out the moral hazard in a prerequisite to moving forward, not to mention of critical interest to the small farmers.

The case study at hand examines one small company Molmilk that suffered after the collapse of the Soviet Union disrupted its supply chain – it was forced to operate at

half capacity and employed just 11 people in 1997 from a high of 57 before the turbulence. Much of the problem can be traced to the fact that a large majority of milk in Moldova comes from 'procurement stations' where small farmers distribute their milk from one or rarely more cows. This feature of the market led to moral hazard problems; in 1998, 20% of milk from these stations was unusable. To quote the authors, there were five cheats:

a) Passing of contaminated milk as fresh
b) Adding water to milk where payment was based on volume
c) Adding lard to milk where payment was based in fat content
d)Adding sheep's milk to cows' milk
e) Defecting on paying farmer for milk

Molmilk solved these problems in two ways. Firstly by simply trying harder to supply milk from more agricultural companies thereby giving another party a greater incentive to work together. And secondly, by contracting more effectively both with farmers from collecting stations and agricultural companies. As this solved many of the informational problems, I will focus on the contracts. In the contracts: Molmilk agrees to pay promptly with penalties for failure, it leased milk cooling tanks to supplies, substandard milk is simply returned with penalties and bonus tied to the milk's quality (measured by acidy, fat content, ammonia content among others). But perhaps most importantly, each batch of milk was to be tested at,

> "both the farm, in the presence of a representative of the farm and the driver of the milk tanker, and at the dairy...with chemical reactive to analyze fat content, acidity and density(...) so that the quality of milk could be determined for each batch of milk from every supplier. In this way, farmers that tried to sell counterfeit/substitute milk could be identified...once producers realized that each batch of milk would be tested and poor quality

milk rejected, a process that took about two months, the level of (attempted) cheating fell by approximately three-quarters"

Naturally, Molmilk coupled these efforts with a marketing campaign to restore confidence in the brand. After all, Molmilk was now operating in a competitive market.

Quite a simple contract with effective results, but a question remains – who decides the cut off point for rejection? Also, it is pointed out, that there are different qualities collected, but Molmilk doesn't label separately because they have assumed there is no market for it. It is also worth pointing out the today, Moldova has signed an association agreement with the EU and hopes to export milk one day soon. So, a market has been brought up to European standards, but are the informational problems solved? No, only the basic food safety issues are. But we have an example of a consumer (just in this case a company) playing an inspection game. They are able to cost-effectively inspect all the milk and pass this assurance on to consumers through marketing, i.e. signaling.

Other authors focus on branding from the marketing standpoint, but never-the-less we see an element of signaling quality. De Wulf et al. (2005) examine name brands vs. store brands and how consumers perceive each. Branding is a signal and certificate in its own right. In the classic view of price discrimination, there are usually two groups and hence two prices. An example being store brand vs. premium brand. However, recent evidence has shown that store brands may capitalize on their store's reputation and provide some competition. The authors show that stores are able to build brand loyalty that carries through to their good branded with their name, and in many cases even succeed in being seen as a premium brand. In other words, the only signal needed is to show some association with the store and this becomes a powerful signal of quality. This correlates with the findings of Oceana's DNA analysis of fish markets – national stores were less likely to mislabel fish.

Of practical interest to this thesis would be to know how people respond to signals of quality in an experimental settings. Richardson et al. (1994) show that extrinsic signals of quality are more important for predicting likeliness to buy as well as

rated quality. They form an experiment to test the effect of extrinsic, i.e. "price, brand, name, and packaging – which are not part of the physical product..." vs. intrinsic, i.e. "ingredients, that cannot be manipulated without also altering the physical properties of the product", on consumers' perceptions of quality. Their hypothesis is that a focus on quality as opposed to price could produce favorable perceptions of store brands leading to increased brand/store loyalty and a sustainable competitive advantage.

Richardson et al. (1994) design an experiment to test how shoppers perceive the quality of various goods by setting up a stand in a shop with various goods. One of their goals is to check if store brands really rate poorly on their quality – for example in the literature, most studies rely on recall and the authors wanted to eliminate this bias. Also, they want to test Schellink's (1980) hypothesis that consumers are weary of making a low quality buy and tend to rely on extrinsic cues that they can be confident of (Note, this thesis hopes to call that into question). They have a packages of food, for example crackers, cookies and juices, of various brands, namely some store brands and one national or name brand market leader. They also display the price of each package. One by one they single out consumers to test a combination, meaning that they had to test all the possibilities such as name brand package – name brand product, name brand package – store brand product, store brand package –name brand product, and store brand package – store brand product. Also noteworthy for this thesis, is the fact that the authors consider the goods and ingredients of equal quality and hence see nothing unethical about hoodwinking their taste testers. This setup then allowed them to ask the consumer to fill out a form and rate the quality, as well as how likely they would be to buy.

They find that national brands do better extrinsically. That is, every time consumers thought that they were sampling the 'high quality' product, they rated it tastier and more likely to buy. The authors take this as evidence that the signal of quality has a decisive effect on the outcome and explains the poor market share of store brand goods.

We find another interesting study as it reports on a natural experiment. Mojduszka et al. (2000) assert that markets were inefficient in providing information

when given a choice. They take advantage of the natural experiment provided by the 1994 Nutrition and Labeling and Education Act (NLEA) in the U.S. that enforced stricter requirement for nutritional labeling. This then allows them to test the level of labeling before and after an exogenous shock.

These results imply that a reliable and robust signal of quality is highly correlated with the purchasing decision. They also imply that the strategy set for creating this signal is larger than the classic high/low quality good differentiated by price/packaging. Their goal is to test Grossman's (1981) 'totally effective quality signaling thesis' – as above, when manufacturers can make ex-post verifiable claims of quality, they will make them, and those who don't are assumed to be of inferior quality.

Their goal is test his hypothesis by examining which products chose to provide complete nutritional information prior to being forced to adapt a new labeling standard. I.e. to test whether, "[m]manufacturers of low nutritional quality brands would not want to disclose this information to consumers. Or on the other hand, the estimated coefficients of desirable nutrients...would be positive...". They also want to test whether the coefficient on price is positive. This experiment is of interest to us even though the authors are concerned with nutrition; we can directly evaluate the willingness of producers to provide information in the absence of any legal impetus to do so.

The authors use a logit regression to predict the presence of a nutritional panel as a function of certain nutrients as well as price. The results are not encouraging; the "test of a models of totally effective nutritional quality signaling provided mixed results...". Some times their hypothesis proved true, others, not. Even though consumers were provided with a reliable signal, the authors conclude that mandatory labeling was and is an effective solution for increasing information available to consumers

There is a long list of literature on certification. Holleran et al. (1999) point out that consumers may have market power an demand quality assurances. Or, a firm not undergoing a quality assurance process will be barred from international markets. Hence the market can be self regulating. But he also points out that many of these mechanisms can serve as barriers, for example when national producer organizations create unique quality assurance systems as a way to distinguish themselves from

outside competition. Hatanaka et al. (2005) arrive at a similar conclusion that certification is the bedrock of the global food industry but point out that the process itself is far from ideal; an auditor has a strong incentive to approve the audited. We will return to this later in more detail as it is crucial; certification is the de facto solution we see every day, yet blighted by its own information problems.

The constant in all the literature is to identify the theoretical tensions resulting in market failures and suggest a few mechanisms to alleviate them. It is also true that many of the suggestions have been implemented in various forms. The previous section casts doubt on how much improvement there has been. It is probably true that every day more and more people have access to both safe and high quality food. But it also would appear to be the case the huge numbers of people are victims of food fraud.

3. Key Models

In the following subsections, I will explore in-depth three theoretical models that cover the most important elements to understand about the market. The first model, perhaps the most technically demanding due to its dynamic nature, is used to illustrate the importance of monitoring in a basic series of producer/consumer interactions; it is hard to escape the need for some form of monitoring and any food system must respect this fact and for this reason we must start with this model. It is also the most intuitive place to start if we consider the essence of a producer/consumer relationship at its simplest with respect to interaction. The next model is a progression in that it allows the consumer the strategic possibility to investigate. The first two models discuss different dimensions of the problem, and the last will cover another – globalization and its consequent risks.

The order of the models is in many ways irrelevant – their point is to provide simple yet convincing theoretical proof of the inescapable sources of informational problems. The problem as well as the solution is meant to be taken as a whole.

1.3. Monitoring as a solution

"Asymmetric information problems occur because food producers know whether they have used the appropriate methods to achieve the desired quality attributes, but consumers only know with certainty what the producers' quality claims are or what the label says." (McCluskey 2000) He points out that in a simple game there can be no market for credence goods and that the market would collapse à la Akerlof in the absence of other mechanisms. This is because, "the consumer does not know the quality of his/her purchase even after consumption, it is not possible for the consumer to punish the producer by not purchasing the product in the future as a response to a false quality claim."[2] He investigates monitoring as a common way to ensure a market for credence goods by making use of an repeated extended form game modeling the influence of unknown monitoring levels on a producer's decision to claim organic, and on their subsequent choice to actually produce goods of corresponding quality. And finally the consumer's choice to buy the good or not. His model, despite the simplifying assumptions is the best starting point for any discussion of the issue – it allows us to understand some essential features of what is happening.

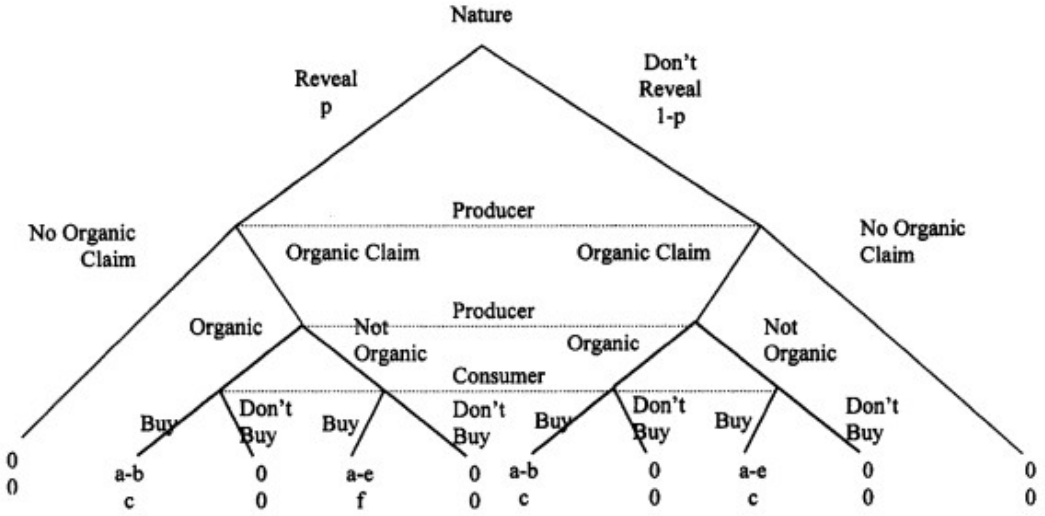

Figure 5. Credence Good with Monitoring

[2] He also points out the possibility that there doesn't need to be monitoring to support the market, but perhaps the credence good is fashionable, or the alternative is offensive to people – in some cases this might really explain much of the premium.

Above we have the extensive form game tree I just summarized. Nature makes the first move and decides the level of monitoring; this is unknown to all parties. Then the firm may decide to make an organic claim or not. They then decide to follow through with their claim, or to cheat. Then, the producer makes the buying decision. The consumer only wants to buy an organic good. As usual, the dotted lines represent information sets. In this case, the dotted lines portray the fact that the producer will not know whether they will be monitored when making their decisions, and neither does the consumer know if the good has been monitored when they are making the purchasing choice[3]. The producer's utility if price minus cost to produce – by assumption the cost to produce organic is more and hence $b > e$. The consumer receives utility $c > 0$ from consuming the good. They receive $f < 0$ if they consume a good they then learn is not organic. It is not hard to see that in a single stage game, the producer never will produce an organic good because it simply doesn't pay for them to produce a more expensive good.

The main point of the game is that the level of monitoring is decided exogenously and we then analyze the possible equilibria. One thing to notice about the tree is that with probability p, we have a game for an experience good; the consumer receives $f < c$ after consuming a non-organic good because they are 'informed' by the monitoring system. And with probability 1-p we have a game for a credence good. In this situation, "it is not possible for the consumer to punish the producer by not purchasing the product in the future in response to a false quality claim." Clearly, the market hinges on monitoring.

As we are interested in sustaining a market for organic goods, we must consider the game in its repeated form. The question is, does it pay in the long run for the firm to produce organic, i.e. in an infinite game? It only makes sense to ask this question because now the consumer has the possibility to punish to producer by not purchasing a good. The producer's strategy (one possible) is to make an organic claim and produce

[3] One might object that a responsible monitor would inform the players. That is akin to an inspection game and considered next. For now, if one likes they may take this simplifying assumption to represent the possibility that in fraudulent goods are only noticed after they have been on the market for some time.

an organic good in the first period. If the consumer bought it, continue in each proceeding period to produce, otherwise, don't make an organic claim. The consumer's strategy is to buy in the first period, and then buy in all following periods as long as the producer doesn't get caught cheating. McCluskey assumes that the consumer's strategy is common knowledge and that only the producer knows his own. This is realistic enough. This leads to two situations with two different payoffs, the equilibrium payoff and the deviation payoffs. Of course the equilibrium can only be sustained if the equilibrium payoffs are higher. This leads to conditions on the level of monitoring that are requires for such an equilibrium to exist.

We proceeded thanks to the one-shot-deviation principle, which says we only need to check one-stage deviations to find a subgame perfect Nash equilibrium. Furthermore, due to discounting, clearly a one-shot deviation in the first period is the most profitable for our producer. So, if we find conditions under which the producer does not want to deviate in the first period, then we can be sure that the strategies form a subgame perfect Nash equilibrium.[4]

McCluskey

Table 2. Credence Good with Monitoring Payoffs

	Equilibrium Payoffs	Deviation Payoffs
Producer	$\frac{a-b}{1-\delta}$	$a-e+\frac{\delta(1-p)(a-b)}{1-\delta}$
Consumer	$\frac{c}{1-\delta}$	0

In the above table, we see the payoffs to the equilibrium strategy and the deviation. Again, a is the price, e is the cost to produce a normal good, b the cost of

[4] S. Nageeb Ali (2011) provides an excellent formal as well as intuitive explanation of the one-shot deviation principle. Also, note, the equilibrium supported is not unique, we could construct others.

producing an organic good, c the value to the consumer of an organic good, delta is the discount rate and p is the level of monitoring, i.e. if p=.9, and we produce a non-organic good, we will be caught 90% of the time. For the producer, the equilibrium strategy's payoff is the present value of the price they receive less the cost of producing organic. The payoff to deviating is the one-time bonus of the price of an organic good minus the lower cost of producing a non-organic good plus the present value of all future payments from producing an organic good which the firm gets assuming that they didn't get caught cheating in the first period.[5] To restate, if the strategy's non-deviation payoffs yield higher utility to the agent, then we have found a subgame perfect Nash equilibrium. Comparing the producers payoffs, and rearranging for p, we have:

$$1 \geq p \geq \frac{b-e}{(a-b)}\left(\frac{1-\delta}{\delta}\right) \geq 0.$$

One of the first things we notice is that, if the cost of organic goods compared to non-organic is large, i.e. if b goes up, then the probability of getting caught must be high to support an equilibrium of repeated purchases of organic food. Similarly, if the cost of non-organic inputs falls, then we need increased monitoring. If we lower the price, then we also require higher monitoring. The level of monitoring also depends on how we discount the future payoffs; a low discount rate means we need high levels of monitoring. In other words, if future profits are less valued today, then we need more monitoring, which is intuitive because the deviation strategy will be more appealing.[6] As a final note, why is only this equilibrium considered? There are many. Because this strategy is the strategy of interest, one that supports a market for organic food. And this is a powerful result; without monitoring, there is no incentive to produce high-quality food. It is also intuitive. But the model gives us more. We live in a high-cost world – it

[5] The deviation payoff is $a-e + (1-p)[(a-b)\delta + (a-b)\delta^2 + (a-b)\delta^3 + ...]$, again, the one time bonus of the cheaper production price plus the discounted future income from producing organic that the producer only receives if they didn't get caught in the first period. Apply the formula for the sum of a geometric series to arrive at the equation above.

[6] Yet more evidence short-termism is damaging.

simply is expensive to produce quality things. We also live in a competitive world – prices are constantly pushed down. In other words, forces fundamental to the market are also an existential threat.

But of course we are not through with the issue. We have established that for the market to exist, we need some mechanism to ensure honesty. Monitoring as such is one. But there are extensions and monitoring often implies an action, either a reward or a punishment. To come to a better understanding of the effects of such action as well as to take a step towards reality by making the monitoring a strategic choice, I will look to some results from inspection games.

1.4. Inspection Games

The situation we are concerned with is moral hazard and the consequent adverse selection that arises from the inconvenient nature that producers will always have more information than consumers. Taking our inspiration from the simple game introduced above, it will be important to model the very most basic interaction in such a game – to verify the producer's claims or not. The advantage to such an approach is that it provides a simple way to model a more strategic interaction between consumers and producers in a realistic way.

In classic inspection games, we are concerned with compliance; does one pay his taxes, observe speed limits, or follow pollution regulations? In such games, there is no pure strategy Nash equilibrium – only a mixed strategy (Nosenzo et al. 2013). This means that there is always a positive probability of non-compliance, but from a social standpoint, we hope for compliance without the cost of inspecting. Naturally, there are ways to move in the direction of better outcomes - fines or rewards. Nosenzo et al. (2013) point out that in standard inspection games, fines lead to a higher probability of compliance in the unique mixed-strategy Nash Equilibrium, whereas unfortunately rewards lead to an increased probability of non-compliance. I will illustrate this result using a game similar to an inspection game, but the intuition is the following. A fine costs the firm for cheating and this goes into the consumer's pocket. Naturally they are less likely cheat if it is more costly. On the flip side, if we reward the firm for not

cheating, this reward come off the top of the consumer's payoff, so they are less excited about inspecting. The firm knows this and consequently produces at a lower quality.

Nash Equilibrium is a celebrated solution concept, and indeed is very appealing as such.[7] However, when we begin to consider mixed strategy equilibria, the intuition behind NE becomes a bit of a stretch. Furthermore, experimental evidence has shown that NE is a poor predictor of behavior in such games. For example, Ochs (1995) conducted a series of experiments where subjects played 'matching pennies'[8], and their behavior was not what the mixed-strategy equilibrium would have predicted. This has been attributed to the own-payoffs effects. That is, that players reacted to the rewards and changed their strategy accordingly, something that does and should not happen if players were to strictly follow the strategy from a mixed NE.

Nosenzo et al. (2013) investigate the implications of the own-payoff effect on a generalized inspection game in a theoretical and experimental setting. They point out that the own-payoffs effect of a reward would theoretically make compliance more likely in the NE. In their setting, this means that players would react positively to the bonus and be more likely to comply, behavior that is opposite of theoretic predictions. This means that there is ambiguity when evaluating the effectiveness of either mechanism. To address this the authors conduct a series of experiments modeled on a worker/employer scenario where an employer can encourage work by fining slackers or rewarding effort. They find that the, "prediction that introducing bonuses will reduce combined earnings is not supported: the losses to employers are almost exactly offset by gains to workers." Furthermore, they find that the level of work effort between groups that were rewarded and groups that were fined is statistically identical.

By itself this is a powerful result and deserves more attention. But for our purposes, its means that we will later be free to consider not just punishment in all its theoretical supremacy, but the more appealing idea of rewarding compliance.

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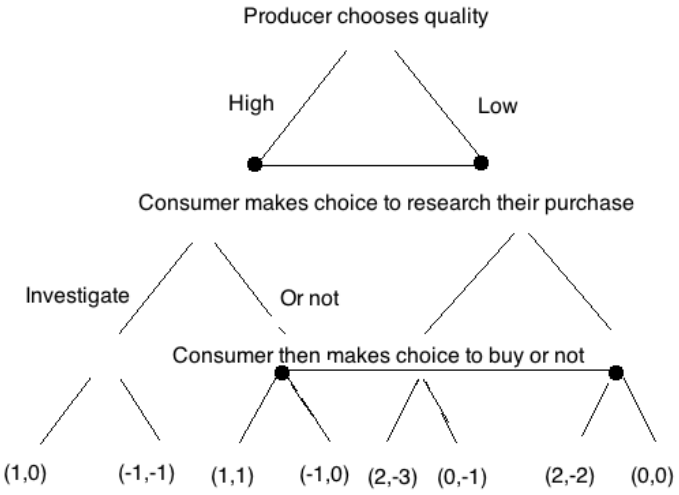
[7] Mas-Colell, Whinston, and Green 1995 provide a list of reasons. Nash equilibrium is a consequence of rational inference, necessary if a game should have a unique predicted outcome, focal points, it is a self-enforcing agreement, and finally a stable social convention.

[8] A popular and simple example of a game with no pure strategy Nash equilibrium.

1.5. Implications for the food industry

As a first step to understanding informational asymmetries in the food industry, we can model the interaction between a representative producer and representative consumer as an inspection game. This game will offer insight into the punishment/reward possibilities as well as be a step beyond the typical suggestion to remedy informational problems.

Now is also a good time to take note of the fact that I am modeling a consumer. Coming from the realm of inspection games it might be more natural to consider official inspectors. On some points, the difference is miniscule, on others, more important, but I think, most importantly, the choice has no effect on the conclusions. Especially if we consider that the public could simply band together and hire an inspector.



The story is the following. The producer chooses a quality, but *always* markets it as high-quality. The consumer then makes a choice to undertake research or not. If they research, they are able to find out the quality. The connected nodes represent private information sets of each player. The fact that quality is discoverable might be a

contentious point. We are modeling moral hazard based on the premise that the consumer does not know the quality of the good but with more or less effort is able to learn its true value.[9] In some situations, the costs are higher or lower to discovering the quality but here I make the assumption that this is represent by a parameter.[10] Another note, in addition to be able to learn the quality of the good, we will consider an experience good. As Akerlof had in mind, McCluskey shows, and we will soon show, only from a slightly different perspective, the market collapses for such a good. Let me reiterate, the point of the model is to suggest several improvements to the market. The fact that we consider an experience good with low-ish research costs is only an assumption made for tractability.

Now I will explain the numbers behind the game. The consumer's payoff is their value less the cost of the good minus a sunk research costs – they do not need to buy/consume. A low quality good is mildly poisonous and this costs is borne after consumption (hence the classification as an experience good). The producers gets the price of the good less any investment in quality. The price for the good is 2. A consumer values a high quality good at 3 and 0 for a low quality good. Research costs both parties 1. That is, a consumer may investigate the good for a price of 1, and the producer may learn how to produce edible food by spending 1 on R&D. In the following matrix, the producer is the row player, they choose H, high or L, low quality, this is the producer's private information set. The column player, the consumer chooses to conduct research I or not, N, and then to buy, B or to reject, R. For completeness, I will note that when the consumer does not undertake in research, that information set contains two nodes and they are not sure at which they are – they are then faced with the choice of buying a good of dubious quality.

[9] In our fish example, the cost of conducting DNA analysis is likely prohibitively high and hence explains the market outcomes. Unfortunately the same argument is true of many other examples. Nevertheless I think the game offers insights.

[10] It is well worth considering the case when the consumer simply cannot find out the true value to represent cases where research costs are very high as they are in many situations.

The strategies available to our consumer are the following. First they decide to Investigate/Not Investigate. Then they decide to Buy/Reject if the good is found to be High quality. Or they decide to Buy/Reject if the good is discovered to be of low quality. Or they decide to Buy/Reject if they didn't undertake in research. A set of strategies that defines all possible actions is clearly composed of 16 different strategies. But fortunately we may eliminate many of these. Our player will always buy if they do research and discover a high quality good. Similarly, they will always reject a good discovered to be of low quality. It is not, however, so clear what they should do when they do not research.

	IB	IR	NB	NR
H	(1,0)	~~(-1,-1)~~	(1,1)	(-1,0)
L	~~(2,-3)~~	(0,-1)	(2,-2)	(0,0)

After eliminating the dominated strategies, we are left with the above game. A quick inspection reveals the common situation that the social optimum is not the Nash equilibrium; we hope that the producer invests in quality and that the consumer can blindly make such a purchase. However in this dystopian world, the least bad the consumer can do is to not waste time researching and not buy the good. The producer is best off not investing in quality. We could imagine that the game isn't played.

Before moving on to mechanisms to improve the outcome, I want to point out that this is not exactly the type of game addressed by the literature on 'inspection

games'. As we saw above, an inspection game has no pure strategy equilibrium. But, here, the added tier of the buying decision create a slightly more complicated situation; we cannot take for granted the players' beliefs about the others intentions at each step along the way.

So what mechanisms exist to improve the outcome? As a preliminary comment, notice that there is no way to *move* the equilibrium, we can only change the game. Whether this is a feature of the simple model above, or a real life fact is debatable, but it is an important feature. But let's change the game a bit starting with suggestions from Nosenzo et al. – the carrot and/or the stick. We can either punish the firm for producing (and lying about it) low quality, or reward them for providing the market with high quality goods. Such a mechanism would be represented by appending a loss/reward function to the producer's payoff (and of course charging/rewarding the consumer with an equal amount). Below I show a game where, upon inspection of a low quality good, the consumer fines the producers 2 and pockets it.

	IB	IR	NB	NR
H	(1,0)	(-1,-1)	(1,1)	(-1,0)
L	(0,-1)	(-2,1)	(2,-2)	(0,0)

We can easily see that here there is no pure strategy Nash equilibrium. That is progress because now the market functions to some extent. We could of course ask what is the equilibrium and how can we further optimize it, but there is little benefit in such an activity for our purposes. Of course, society is very interested in such fine tuning – too high a fine, and the producer will simply leave the game, and too low, and

we will not have a very high probability of every seeing high quality goods. But I want to go on an suggest a further improvement. And I will make a case that there is something unique happening that the literature ignores.

1.6. Other implications – a thought experiment

We now have a situation where theoretically we must punish a dishonest firm for false claims. Or, alternatively/additionally, we may reward the honest ones and hope that the own-payoffs effect is enough to bring the new equilibrium back in the right direction. Good. We can do these things, and indeed as a society, we do take such measures. But, I will argue that we are not done; the model in its many abstractions leaves out a very important feature of this market. That is that there of course many different types of consumers, and the small probability that one undertakes some research effort is essential to the sole firm's strategic decision. Furthermore, as long as there are a few very ambitious consumers, i.e. with a high willingness to inspect (in our equations, a low s), this can influence the equilibrium dramatically.

But let's consider other mechanisms beyond punishment/reward, just as a back-of-the-envelope thought experiment, imagine that different consumers have different costs of research, for some the cost is almost nothing. And then suppose that they could share their information with others in an efficient manner. Then, the firm would play a game where they knew that they would be inspected, and hence their best strategy is to produce at a high quality. But the majority of the consumers would also play a game knowing the quality of the product but save the cost of research. Now we have the social optimal – most consumers undertake no research efforts yet guarantee a high quality product. The strategy for the firm is now fixed, but the majority of the consumers can save the inspection cost.[11]

This small insight gleaned from a tweak to the basic inspection game is significant. We have found a broad mechanism that accomplishes the same task as

[11] One hopes that the 'tough' consumers will continue to undertake research efforts seeing as fellow consumers are freeloading.

monitoring, for example, and arrived at a slightly different conclusion than is commonly proposed. It introduces the possibility that we can reduce moral hazard in the food industry through measures such as improving the media and closer relationships between producers and consumers. There is nothing here that precludes government monitoring and indeed as such it likely can do much of the work at a lower cost than any other solution. But, there is also nothing in this analysis that suggests it is the only option and indeed perhaps encouraging other forms of monitoring would likely improve outcomes at a lower cost. For example, let a few enthusiastic consumers do the work and keep the firms honest through well functioning media channels.[12] Furthermore, as we will see, monitoring will prove in practice to be too clumsy of a tool to ensure a market in many types of goods.

1.7. Conclusions from inspection games

The above analysis hinges in many ways on the chosen values for certain parameters. In many cases, consumer will feel no loss from unbeknowingly purchasing a slightly lower quality. Hence, the social optimal is not as far away. Also, the costs of inspection vary widely depending on the situation. The cost of a consumer to inspect organic eggs used in her pastry certified organic by an American certified certifier in China[13] are far higher than they are for a large company to inspect a local supplier. Such situations certainly change the payoffs and we have to ask ourselves again, how suitable are our solutions? I would argue that more thought should go into mechanisms that lower the cost and increase the benefit to research that depend on all acting parties as an institution or even service could have significant impact on the outcomes.

[12] As an interesting side-note, much of this analysis can be applied to the European Unions approach to agriculture. For example, most regulation is central, but fines are set by member states. But if fines have a direct effect on the incentive to cheat, perhaps fines should also be EU wide? At least, one would imagine that member-states with a high loss from making a bad buy, or a low value on low quality, would support such a change.

[13] A situation allowed by EU law.

1.8. Moral hazard in the supply chain

Starbird et al. (2008) provide an model of food security based on depth, breadth, and event probabilities in a simplified supply chain. Their model offers perspective on ways to mitigate moral hazard in the supply chain and is obligatory analysis as we consider the evolving nature of the food industry. Although the authors focus is on food security, their model is useful for thinking about promises of quality as well.

Their model's goal is to find strategies to mitigate the moral hazard that stems from a complex supply chain; if, as a supplier of fish for sticks, it is very unlikely that any consequences from bad fish, or mislabeled fish trace back to me, then I have very little incentive to take steps to produce them in a manner consistent with how I promised to supply the fish. The authors find several ways to mitigate this risk within their model; they suggest subsidizing the production of safe food, and increased testing and fines at testing stages.

Let's go through their model to understand how it works, and then we can be a little more specific about policy prescriptions. The essence of their model is to show under which conditions the best strategy for a producer is to produce safe food, i.e. that which has a low probability of contamination. The tradeoffs are; higher quality food costs something, may or may not sell at a premium, and that there is always some chance that if they produce poor quality it will not be traced back to them. Starbird at al. present a model that considers the possibility that tests give false positives or fail to detect a danger, but they then admit such things are little studied, have a comparatively small effect, and are hard to manipulate. I will drop such events and only consider the case where tests are accurate, and all products are tested. The problem is still that there is a possibility that a final good failing the quality test may not be traced back to the producer. Using the authors' notation the story is as follows: a producer must decide on a quality, (1-q), to produce, or more specifically, their optimal level of bad food, q. This is a proportion; if q is .3, then 70% of food produced is 'safe'. Then we can understand that this quality decision then determines the proportion of food that will pass the testing phase at the end of its journey through the supply chain and the proportion that

will not.[14] Luckily for the nefarious producers, there is a traceback error, ϒ, that determines the probability that 'bad food' will not ever be traced back to them because it cannot, or simply will not – both of which are plausible. This leads to the following utility to the producer:

$$U(q) = (1-q)*w - c(q) + q * \Upsilon * w - q * (1- \Upsilon) * C_c \qquad (3.6.1)$$

Utility is the proportion of safe food times the price, w, minus the cost of production, c, plus the proportion of low quality and is not traced back times the price minus the case when a low quality good *is* traced back in which the producer pays C_c.

The question of interest is, when is it in the producer's best interest to always make the investment in quality? Approached with a spectrum of costs and quality proportions we can simplify the analysis by only asking, given two cost/quality structures, when will the producer choose to produce high quality.

For c^L, the cost of ensuring low contamination, the producer may produce a product with a low level of contamination, q^L. Similarly for $c^H < c^L$, they may produce a good with a higher contamination rate, $q^H > q^L$. The question is now, when is the expected utility of producing a high quality good higher than producing a low quality good? That is true if the below equation holds. As well as we require that individual rationality holds, i.e. the left-hand side is greater than 0. But in this case it holds by assumption; we can choose numbers such that our producers will play along.

$$\begin{aligned}&(1-q^L)*w - c^L + q^L*\gamma*w - q^L*(1-\gamma)*C_c \geq \\ &(1-q^H)*w - c^H + q^H*\gamma*w - q^H*(1-\gamma)*C_c \qquad (3.6.2)\end{aligned}$$

Now we have various options to move forward with our analysis. One approach is to rearrange and solve for γ, which gives us a function that defines the maximum

[14] Of course one could consider testing at all stages, and indeed hopes that some testing happen during production – but that is not the focus of what this model offers.

traceback error acceptable to producers to want to produce high quality. Doing so leads to:

$$\frac{\left[\left(q^H - q^L\right) * w - \left(c^L - c^H\right) + C_c * \left(q^H - q^L\right)\right]}{\left(q^H - q^L\right) * w + C_c * \left(q^H - q^L\right)} \geq \gamma \qquad (3.6.3)$$

This equation is the starting point for evaluating policy, and as the authors put it, "if true, then the supplier will elect to exert the effort to produce low contamination product...if not, then the supplier will elect to deliver high contamination product." But, first we must make note of some potential problems. First, suppose the left-hand side is negative? That would mean that for any such parameter values, the producer will always want to produce at a low quality regardless of the traceback error. Why? Because that says that the equation is always false because gamma is restricted to be between zero and one. The left-hand side of the above is negative if:

$$\left(c^L - c^H\right) > \left(q^H - q^L\right) * w + C_c * \left(q^H - q^L\right) \qquad (3.6.4)$$

This is an important thing to notice. Suppose we raise the cost of providing safe food, c^L, then it becomes more likely that producers simply won't. Similarly, if we lower prices, w, then it becomes more likely that the best strategy is always to produce at a low-quality. These conclusions are logical, and we do live in a high-cost price-competitive world.

On the flip side, it could be that (3.6.3) is always true, i.e. the producer always wants to producer at a high quality regardless of the traceback. But this situation doesn't seem very likely, and we won't explore it further. Back to the above equation's use in some analysis. Let's check some intuition concerning the traceback error as well.

Claim: All things being equal, if we lower the traceback error, then we also will not need to punish cheaters as much.

Proof: The derivative of the function with respect to the cost of contamination is positive if $\left(c^L - c^H\right) * \left(q^H - q^L\right) > 0$. Since we assume it costs more to produce low contamination products, this is true, and hence, traceback error and the cost of contaminiation are positively related.

This is important if we consider individual rationality – the lower the fine, the more producers will find it rational to play the game. Or, in other words, raising the fine helps induce higher quality – it also could potentially limit the pool of participants. There is no easy solution here.

Claim: All things being equal, if we lower the traceback error, then we may lower the price, w, of food the made it to the market.
Proof: The derivative of the function with respect to w, the premium or transfer payment, if positive if $\left(c^L - c^H\right) * \left(q^H - q^L\right)$ is positive. This is true by assumption.

This is also important if we think that producers live in a highly competitive world. If traceback error is too high, then they simply won't ever want to produce at a safe quality.

Good, now we have established Starbird et al.'s results using a much more strait forward situation. I want to point out the suitability of his model to considering informational problems in a globalized food chain; it is not hard to imagine the gamma is a real and positive and it creates moral hazard. At first glance, the problem seems to be, and in many ways is, an institutional one. And, it is; moral hazard in the food chain is cured by exposing agents to the risk – but this is easier said than done. Recognizing this the authors largely take traceback error as a given and focus on the other ways to ensure food is safe, namely by subsidizing the costs of safe food, paying a transfer and raising the cost fine for getting caught.

But, once again, there are other ways. Starbird et al. take the traceback error as given. However, improving traceback error is also a task worth considering. My

analysis of inspection games presented above is an applicable framework that implies moral hazard can be reduced significantly at all stages of the supply chain, assuming a well-functioning system of information dissemination. I want to point out that this sharing is made possible by technological advancements that people didn't fully grasp 20, even 10 years ago. And better ways to collect, catalogue and disseminate information are exactly how one would reduce traceback error. This then allows for lower premiums on high quality goods as well as less need to inspect and punish.

1.9. Section conclusions

The above models and musings have made the following claim: The market for safe and high quality food can only exist if we have sufficient monitoring, fines, transparency in the food chain, premiums and low costs of production. These all hold to a varying extent. But the reality is that it is expensive to produce high quality, and premiums are kept low by competition. Also, inspecting is not always easy, or cheap. And we certainly are not always able to trace products back to the source. This all suggests that there is existential pressure constantly being applied to the market and there is room for improvement.

But we have also ignored a very important mechanism – producers may attempt to signal their quality. The next section will explore such possibilities as another complementary solution to informational problems in the food industry.

4. Certification

In the above, we have considered the theory behind the informational asymmetries in the food industry – the fundamental fact that the consuming party simply cannot know the truth behind the claims of the producer. Various models in information economics offer a possible solution of third party monitoring. But the research cited, and theory itself falls short of providing a solution; it is simply to vague

about what constitutes ample monitoring. In the next section, I will clarify how we could and currently implement the, previously amorphous, monitoring to ensure a functioning market. I will start with a brief discussion of Spence's seminal work on job market signaling and move on to some insights into certification from audit theory. This will serve as a preamble for a discussion of what is missing from the market and literature that could significantly impact the market.

A logical next step is to consider the means by which a producer may signal their quality attributes – on some level, all signals in the food industry are a certification. A brand is a form of certificate. So is a government certificate. It could be the fact that a national food systems has allowed such a product on to a shelf. It could be a third-party certificate.

1. To certify or not – Spence

But we also need to consider the certificates of dubious quality.

The problem, out of context in the job market, yet relevant, stated by Spence (1973), is that, "the employer is not sure of the productive capabilities of an individual at the time he hires him. Nor will this information necessarily become available...to hire someone, then, is frequently to purchase a lottery." Spence is concerned with perceptions and a potential employee's ability to signal his talent. He considers certain personal attributes unalterable, while some maybe changed and used as a signal. Education is the primary signal. Let me pause here and note that this format differs from that of a producer in the food industry. Education invokes a cost and is a signal of future talent. A food producer can also undertake costly measures, for example organic practices and certification, as a means to signal quality. The are of course differences between the job market and the foodstuffs' market. But for our purposes, it is the possible equilibria that concern us, and they are the same.

Abstracting away from the details with the goal of borrowing a simple idea for its ramifications, allow me to summarize the various equilibria. We assume that the marginal cost of the signal must be lower for those of higher capability otherwise, every applicant will, "invest in the signal in exactly the same way, so that they cannot be

distinguished on the basis of the signal." Then there are equilibria in which signaling will play a role. This is not a radical assumption for the food industry; surely it costs less for an organic producer to get certified as an organic producer, and thus send a signal than a non-organic producer.

Spence shows the existence of a signaling equilibria based on the above condition. In these equilibria, there is a level of education at which employers offer a higher wage to those attaining it, and a lower wage to those who embark on no education. There are two salient features to these: 1) There are infinitely many values for the cutoff level of education, and 2) not all imply welfare improvements.

However, the situation that seems most relevant for our discussion, simply because of the preponderance of signals in the food industry, are pooling equilibria in which a signal conveys no information.[15] This is possible with negatively correlated signal costs and quality, but it is also possible with no correlation. The key necessary condition is that the level of education is sufficiently low. So, we can raise the cutoff, so to speak, to nudge the game to an equilibrium in which signals carry weight. We need to keep this in mind as we discuss certification.

Now is a good time to go into the details of Spence's example to see how the conclusions carry over to the food industry. The goal of which is to find theoretical conditions that ensure descriptive signals. For clarity and consistency I will borrow Spence's simple example and explain it. As he himself notes, "an example does not prove generality. On the other hand, if the reader will take reasonable generality on faith, the example does illustrate omen essential properties of signaling equilibria".

The story is the following. An employer is faced with the decision to hire knowing that there are two distinct groups of workers – a proportion (1-q) of a population with productivity of 2 who belong to group II, and the proportion (q) with productivity of 1, belonging to group I. For now, suppose the cost of education is y for group I and y/2 for group II. An equilibrium is found when the employer's beliefs are

[15] Or rather, Spence's work is most relevant to explain this situation and I think it is worthwhile to consider the theory a bit deeper. Obviously in the food industry we see a preponderance of signals that likely do carry information, or separating equilibria. I will handle those later with a different model.

confirmed as the employee's traits emerge over time. Our main interest is an equilibrium in which signals carry no weight, that is, in which both groups undertake some level of educational investment y*. The beliefs which lead to such a situation are the following;

If $y < y^*$: Group I with probability 1;
If $y \geq y^*$: Group I with probability q, and group II with probability 1-q

Those being the beliefs, our employer should offer the follow wage schedule:

$Y = 0$: w^l
$Y = y^*$: $w^l q + w^h (1-q)$

Notice, if y is less than y*, then the job seeker sets y = 0 because anything else incurs a worthless cost. Similarly, $y > y^*$ is not possible and will be set to y*. Also Spence arbitrarily chooses 2 and 1 for w^h and w^l respectively. But this is not necessary. In fact the employer may have a more optimal schedule in mind, but we just need to ensure that the wage schedule is rational, i.e. that the expected payoff if worth the cost. We will check this later. It does not affect the question at hand and I will adopt these values for sake of simplicity. So, to ensure the equilibrium where all participants signal, we must ensure that signaling is optimal for the job seekers, that is, the wage minus the cost of schooling must be greater than the wage if they didn't go to school. So we must have:

Group I: $2 - q - y^* > 1 \Leftrightarrow 1 - q > y^*$
Group II: $2 - q - y^*/2 > 1 \Leftrightarrow 1 - q > y^*/2$

Notice, if this condition holds for group I, then it also holds for group II. Let me sum everything up: If $1 - q > y^*$, and all employees invest in education, then the employer's beliefs as above are confirmed, and the equilibrium is for both groups to invest in y* of

education because it is optimal for them. It's easy to see that the wage bill is exactly equal to the productivity. There is another noteworthy feature of this outcome; it does not depend on the costs of signaling being correlated to productivity.

This equilibria is possible when the signal is sufficiently small investment in education. As long as we require signalers to push beyond a certain threshold, then the signal, because of it's costs and the negative correlation, will carry weight.

What is the significance for the food industry? If we consider signals such as 'premium' packaging, then we are certainly in such an equilibrium. But such a case is not really the main point. Even if we can safely assume negative correlation between quality and cost of attaining said quality, we still have to worry in some sense that products carrying some signal of quality, are not really what they say they are. Support that there are some certificates available to producers to attest to their 'achievement', then if the bar is not high enough, all producers will opt for the signal and the market will be left wondering, to be more specific, offering a lower price, or perhaps cease to exists.

I want to emphasize again, that while a bit different of a setup, and certainly not an accurate picture of reality, the situation captured by Spence's model is a real worry in the food industry. Sending a credible signal is the only way to alleviate the problem. But this is not strait forward and it is not hard to imagine that many signals carry no distinguishing power whatsoever.

With this warning, let's move into a more detailed discussion of certification, the most plausible way to signal quality. Let me just note, that the point of a certificate is to solve the above problem by providing proof of qualities that where up until know either unknown of inaccurately signaled.

2. Certification – audit theory

When we think of monitoring or inspection – be it government or third party, the discussion boils down to one of certification. When we see food on the convenience store shelf, it effectively carries its institution's certificate, as well as those of any third

parties who's approval the producer has sought out. But this deserves some attention – we need to define a certificate. It is a seal given by the certifying agency guaranteeing that the item carrying it conforms to the standards set out by the certificate's standard owner. The standard owners are those who define what it means to carry their certificate, i.e. what minimum quality attributes, environmental concerns, working conditions, etc. does it take to earn such a certificate. In practice, there are many different accredited certifying bodies who are in charge of the actual audit. (Jahn et al. 2005). This will allow us to draw on a rich literature from audit theory when we seek to understand this process. It will also become clear that certification as monitoring used to ensure a market above is far from simple to implement.

Hatanaka et al. (2005) suggest that third party certification is an essential element to the food industry because globalization, consistent with our above conclusions, "has made it increasingly difficult for nation-states to regulate food safety and quality practices." Which implies a need for a stricter assurances of quality. They even note that, "rather than 'neutral market lubricants,' supermarkets increasingly view agrifood standards as strategic business tools...whether to gain access to new markets, to coordinate their operations, to provide quality and safety assurance to their consumers, to complement their brands, or to define niche products and markets." They define third party certification as institutions that are independent of producers and more agile in their service than governments. However, *their* business model is itself subject to informational problems. Put succinctly by Jahn et al. "it cannot be taken for granted that the auditor – or the certifier - will act benevolently. Indeed, the audit will be conducted as a business," i.e. cost minimizing.

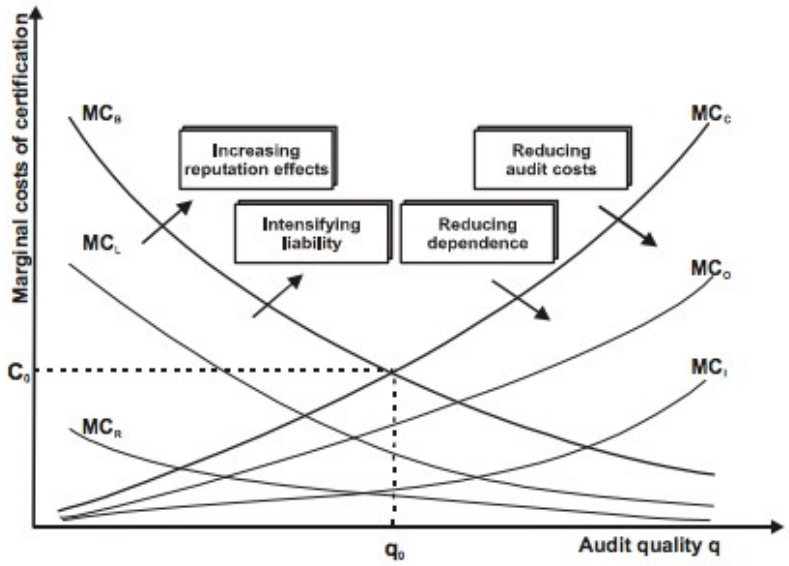
Hatanaka et al. suggest that government regulation is simply unable to keep pace with the developments in consumer's preferences and the expansion of different quality attributes (mostly credence). While the raison d'être of third party certification started with a need for third party, i.e. independent, certification, the market has evolved in such a way that a certifying body's, "objectives are strongly influenced by the marketing strategies and economics concerns of the major global supermarket chains." And hence many global supermarket chains as well as restaurants insists on third party

certification. They also point out that another function of third party certification is that it allows for the risk to be shifted to the certifying bodies, at least to some extent, that if there is a problem, it is also a reputational blow to the organization that certified the product.

Jahn et al.'s audit theory model[16],will provide a theoretic starting point for policy suggestions to improve certification schemes and hence improve outcomes in the food industry. The model is based on rational and risk neutral agents who minimize costs by choosing and optimal audit quality. Before delving into their model and its implications, I want to go over the assumptions that the proceeding analysis takes for granted. We assume that the goal is to improve audit quality. But what we mean is that we seek to improve welfare by ensuring the existence of a market for credence goods. The authors point out that, "an optimal level of audit quality may exist beyond which the costs of a further increase of quality exceed the additional benefits...however, the low costs of certification in most systems suggest that the current audit quality is suboptimal." I would also point to not-unheard-of scandals and the need to counter lengthening supply chains as a reason that audit quality might not be keeping up.

Allow me to explain the pieces of their model. The certifiers increasing marginal cost line MC_c is composed of the marginal cost of the inspection, MC_1, plus the opportunity costs of the loss of the client, MC_0. To be clear, the more thorough the audit, the more costly it is to the auditor and more likely it is that they lose the client – their zealousness is burdensome in that they might just uncover something leading to a failing audit.; what producer would hire a company to fail certification? In addition to these costs, there are the marginal costs that are decreasing in the audit quality, i.e. the costs related to ersatz inspection being discovered. These in turn consist of losses to the certifier's reputation, MC_R, and the potential liability, MC_L. The optimal is clearly at the intersection of these two lines, reproduced below.

[16] Simplified from Müller 2004. Bilanzskandale. Eine institutionenökonomische Analyse., Perspektiven der Wirtschaftspolitik.



This tractable model offers plenty of tried and tested ways of improving audit quality.

One way to improve audit quality is to increase the liability to the audit firm. Thus increasing the marginal costs of the audit and shifting the MC_L line to the right. While this is a seemingly strait forward suggestion, the authors suggest that without stricter institutional oversight, such as in financial markets, this effect is likely subdued. This is because of the fact that increased liability is only effective as long as insurance premiums do raise the cost of the audit prohibitively high. In the financial context this effect is still debated.

A second way would be to increase the reputation effects. The greater the auditor's reputation, the higher the marginal cost. In other words, they have more to lose from a 'bad audit' hence shifting MC_R to the right. This can be effective in the food industry; a respected certification is a more effective signal, which re-enforces its reputation effects.

Third, and an interesting option when considering the food industry is that by reducing the dependence of the auditor. In other words, curtail the practice of 'low-balling', which is when auditors low-ball the price of the audit to win the business

hoping to lock in future revenues. This however creates a dependency of the auditor on the producer. So, if an auditor is dependent on their client, the costs of a strict audit are higher. By reducing this dependence, we are shifting the MC_C curve right and ensure higher audit quality.

Another point is that performing an audit can serve as a way to enter into a consulting relationship. This profitable arrangement however increases the marginal costs of losing a client, that is, shifts the MC_0 line to the left and reduces audit quality. However, it can also be a source of knowledge leading to better practices, hence the overall effect cannot be determined. There is little research into this effect in the food industry, but the two main seafood certificates for fisheries management, MSC and NSF offer consulting services. One has to wonder if this cozy relationship is detrimental to the organizations main purpose, to provide certificates.

The above, as well as the fact that there are often many auditors serves to keep the costs down and improve the audit quality. But here, we need to take note of the fact that the auditors' interests may not align perfectly with the standard holders'.

As a final avenue of improving welfare, the authors suggest that improving training, equipment and moving to 'risk-oriented auditing', taking inspiration from the financial industry again. This means that there should be more resources in the audit in those areas that are at a higher risk for fraud.

5. Conclusions

1.10. An Idea

The above illustrates that to solve the informational problems inherent in the food industry regulators should pay some attention to how he various certification processes are evolving. To complete the circle, so to speak, we need to think about how consumers' role in this process. What I mean is that most governments offer some standards, processes, and inspections. Where they are not diverse enough to fulfill the expanding consumer palate for credence goods, they allow third party certification to fill in the gaps. To stop here would be naïve. The discussion above of certification implicitly

assumes that a consumer demands particular attributes and producers/governments use certificates as a means of credibly signaling in response. But people are lazy, that is, there is a cost to any research effort – and here it is understanding the certification process. This is the same phenomena as above in section 3.3 when the ideal situation is the impossibility of high quality goods being provided and no inspection effort. Now we want high quality and focused/applicable certification without the work, i.e. who wants to create standards and manage audits. Lowering *this cost* is what is truly necessary for a robust market. But we, at the same time, need to mindful of the worry that certificates don't carry enough weight to be used as a credible signal.

As alluded to before, I will appeal to the expanding amount of information being created and disseminated daily. The following proposal is simply a thought experiment that is an attempt to explain how to enact many of the above policy suggests with one fell swoop. It is not the only way, or the best way – but simply serves to point out that *all the concepts* used in the above discussion where first created in a time before the internet and crowd-sourcing. The above suggestions are at best a disparate grouping of rules of varying feasibility. Also, one of the key shortcoming to the system today is the lack potency. As Jahn et al. point out,

> "the only way to detect fraud is the direct monitoring of a company's internal production process. For most third parties, for example, consumer agencies or other stakeholders, this is not feasible, as only the public authorities have the right to conduct investigations within a company. Additionally, these rights are restricted to cases of suspected contravention...Furthermore, for a comprehensive control to be exerted, sufficient public manpower and budgetary means must be available"

In other words, the reality is that the information problem and its theoretical and policy solutions are fundamentally flawed. Whereas the following is one simple idea that addresses nearly all of the problems mentioned in this paper.[17]

A platform for managing certificates' standards and audits would shift all of the lines in the above audit model in the right direction. To be more specific, suppose there was someplace where:

1) All of a good's certificates are in one place
2) The certificates standards are concisely explained
3) The audits are verified
4) The producer's track record is available
5) The platform is constructive and rules based

Likely the most controversial in the above principles would be to keep it concise – anything more than that that is already on a package is pushing it. Suppose finally then that there is such an organizational structure.

Then, the signaling becomes much more effective from a producer's standpoint. They have after all made a non-trivial investment in producing at a quality level consistent with such certification, but they need to signal this to the consumer. For example, there are many certificates above an beyond organic, but very few people with bother with the details. Furthermore, the system, as it is now, presents to us most goods with the 'government certificate' or fewer goods, with a host of little third party certification badges, and very few people know much about either or have the resources to find out. Lowering this barrier only improves the accuracy of certification and broadens the market. Furthermore, if certificate's meanings are clearly enumerated in one place it prevents them blending together as a signal-less decoration.

If it becomes easier for more parties to take part in the audit, suddenly the audit becomes cheaper. In fact, it is entirely possible to imagine the business model of being

[17] Perhaps the reader will find the suggestion easier stated then implemented. I would answer that that same has been said of all of the innovations of our century.

an auditor being undercut by anyone willing to contribute. This reduces the incentives for cheating in the audit. Similarly, if we are able to concentrate the track record of a company and/or certificate in one place, we raise the reputational costs.

1.11. A final word

This thesis has suggested that a pervasive problem requires a broad solution. Decades of research suggesting 'proper monitoring' only scratch the surface of an issue that is deeply ingrained in our everyday life. The baby steps in the right direction are all susceptible to manipulation and hence failure and in many ways we haven't moved past Akerlof's situation.

The policy that I would suggest is to centralize the system. Inspection and certification should play a larger role. As all my sources point out, a big enough slap on the wrist is a proper incentive, but it works far better if other players in the market hear about the fine. We have come far in provisioning of safe food thanks to simple ideas from the sources cited above (and numerous others) but we have also sped off in a direction of bewildering marketing of dubious value for those truly interesting in a robust market for something as simple as healthy and sustainably produced fish – frankly a rather pedestrian demand. But if this century brings the progress of the previous, that might be ok.

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